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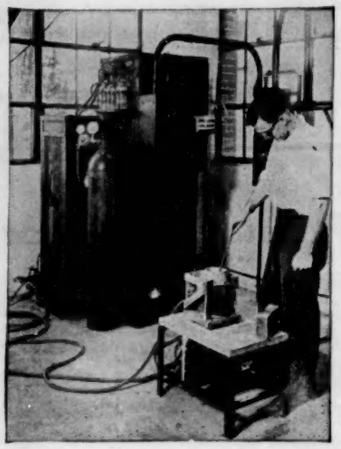

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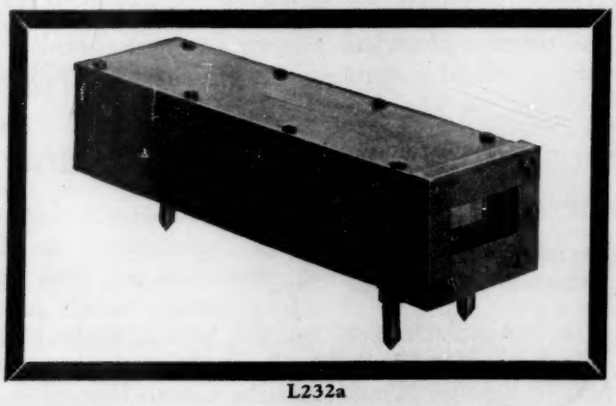

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THE DEVELOPMENT OF SCIENTIFIC RESEARCH IN THE SOUTH[1]

By GEORGE J. FERTIG

ALABAMA ACADEMY OF SCIENCE, BIRMINGHAM, ALABAMA

FROM the very start of colonization on the Virginia Coast at Jamestown in 1609 and from even the occasion of the explorations of DeSoto in 1539 or La Salle in 1687, the fundamental bases underlying the settlement of the South in its various areas have been precisely different from those responsible for the colonization of New England, the settlement of the Middle West or the migration to and the building up of the far western sections of the United States.

We begin this treatise on the "Development of Scientific Research in the South" with such a statement because of the belief that a study of the historical background of the South in contrast to the historical backgrounds of other sections of the country is entirely essential to an understanding and appreciation of the trend of the South toward the solution of its numerous problems through the application of science. To discuss such a subject as research development requires previously a knowledge of educational conditions, of political influences and of industrial tendencies, since conditions in the South as regards these aspects were precisely unique.

In reality the South should not be considered as a homogenous unit inasmuch as the manifold reasons for colonization and growth of its many subdivisions were wisely diverse. The individual states came into being under considerably variant circumstances, their educational institutions under equally different influences, but withal it may be said that whatever the original manner of territorial settlement, growth or advancement the Civil War served as perhaps the most powerful factor to effect homogenizing of political thought, educational progress and industrial activity.

[1]The address of the retiring president of the Alabama Academy of Science, Birmingham, Alabama, March 11, 1932.

The ante-bellum South had no system of public schools such as that of New England or of the more recently settled sections of the country. Its first public-school system began in the days of the reconstruction, although certain of the Southern states had provided earlier in their administration for public instruction. More often the sons of the more wealthy planters, after being provided with a very moderate amount of training, returned to administer plantation affairs instead of continuing their training through academies or Northern colleges.

While the higher institutions of learning in the South were with some exception established through periods comparable to those during which the corresponding institutions in the North were begun, the progress made in their development was many times retarded. Student attendance and financial support retarded the foundation of chairs in the sciences. Training in scientific subjects in particular was put off—even if regarded with favor—in preference to subjects which might be taught without costly equipment or special facilities.

Washington and Lee organized in 1749, the University of Georgia in 1785, Washington and Jefferson in 1787, the University of Tennessee in 1794, the University of Virginia in 1819, the University of Alabama in 1831, Tulane University in 1834, Duke University in 1838, Louisiana State in 1860, the University of Kentucky in 1865, Alabama Polytechnic Institute in 1872, Vanderbilt University in 1873, Georgia School of Technology in 1888 and the University of Florida, organized in 1905, were much slower in development of the sciences than were Harvard University, established in 1636, Yale in 1701, Columbia University in 1754 or Massachusetts Institute of Technology in 1861. There were many reasons to account for the substantial difference in progress of Southern colleges as compared to Northern colleges. Some of these may be traced to the different degree of development of the communities, to financial difficulties, to difference in states of industrial attainment and to precisely different pursuits followed by the inhabitants of the respective territories.

Whatever be the reasons for the slowness in the development of scientific departments in educational institutions they had a telling effect upon the rapidity with which science was applied to the advancement of industry. To be sure, the political problems with which the South was faced during and after the reconstruction were many. The first trend after the war was to return to agricultural pursuits, but gradually movements developed toward greater and greater utilization of the various Southern natural resources. Manufactures increased, using raw materials throughout the South, and with the advent of manifold processes came the demand for further knowledge for the improvement of products, for the establishment of new products and for the study of new methods of manufacture on the part of industry. These demands of industrial progress made distinct requests for assistance from chemistry, physics, medicine, geology, mining engineering, electrical engineering and chemical engineering. All these factors had important influences upon the general attitude of the inhabitants of the Southern states in regard to education and particularly toward higher education and the opportunities which it afforded in industrial endeavors.

Research, in the sense in which we use the word today, does not find a place until a status of higher education has been made possible. Scientific research in particular, hardly without exception, demands the expenditure of considerable money. The services of scientifically educated individuals are required. To provide these requirements took the South many years, even after the advances of the sciences of medicine, chemistry, mechanics and allied fields were sufficient and available to human knowledge in this country. It was necessary to send her prospective educators to the Northern states or abroad for graduate work and to augment her faculties of higher institutions with men native to the North.

It was necessary to provide facilities for the basic training of its students in the sciences. Considerably long periods have been required for her educational institutions to assemble funds for the customarily expensive equipment for research. Time was demanded also to grant vision as to the problems to be solved. To-day there is being conducted a great deal of scientific research in the South in educational institutions. Three hundred and seventy-six researches are under way at thirty-one of the larger colleges. It is by far at these larger centers that the predominance of investigations exists, since forty-six of the smaller schools have but thirty-one problems in progress of solution. Thirty-five of the Southern educational institutions have no scientific researches at all under consideration, although it is much in evidence that many of these institutions are paying a considerable amount of attention to technical investigations, though lack of enthusiasm or encouragement, lack of buildings or equipment and lack of library facilities handicap the efforts made.

The South is blessed beyond any other section of the country by its temperate climate, its abundant rainfall, its many raw materials of industry and its excellent facilities for all varieties of transportation of industrial products to the wide world. During the last thirty years increasing attention has been paid to development of raw materials into finished products

of much value. Although starting the race of industrial development much later than the other sections of the country in the last years, the South has produced 12 per cent. of the value of manufactured products of the United States, 22 per cent. of the value of mineral products and 28 per cent. of the value of agricultural products.

To say that scientific research did not have an important part to play in this remarkable recovery and sterling advance to a status of industrial prominence would be to omit paying homage to a powerful and effective servant. The recent development of the sciences in the South has not been confined to the mere transplanting of chemical or other scientific processes developed elsewhere to this virgin industrial soil. New things have been accomplished, examples of which are to be found in the naval stores industry, the electrochemical field, the agricultural field, the progress made in the utilization of various clays, blast-furnace slag and minerals, the advances made in paper manufacture from long-leaf pine, the utilization of by-products of the cane-sugar industry, the utility of by-products of the cottonseed and the endeavors that have been made in applying science to natural gas and petroleum. No better way of emphasizing the importance of some of these attainments could be adopted than to permit a few scattered examples of research accomplishment in industrial fields to speak for themselves.

RAYON

Rayon is a radically new textile material, having chemical and physical characteristics entirely different from silk or cotton. Natural silk is an animal fiber produced by certain worms and some spiders. The process of fiber development is long and tedious and consumptive of much material. Worms consuming one ton of mulberry leaves produce only twelve pounds of silk fiber. To produce an "artificial silk" having near strength, beauty and softness of the real silk induced scientists to search into fields offering satisfactory forms of cellulose. To the chemist, cellulose, whether obtained from cotton or wood, is an alcohol similar in type to glycerine. If we treat cotton with nitric and sulfuric acids we obtain cellulose nitrate. This cellulose nitrate, when dissolved in suitable solvents, produces a solution which can be forced through a metal or glass die containing a number of fine holes. On removing the solvent, fine, thread-like filaments are produced. If next the nitric acid radical is removed cellulose in the forms of fine filaments follows. These filaments can be twisted together to form rayon thread. Acetic acid may be substituted for nitric acid to produce by still another process a cellulose acetate rayon which differs from the nitrate rayon by being inflammable. A third method, the cupra-ammonium process, produces cellulose threads by a still different procedure.

At the present time approximately 33,000 tons of cotton linters is consumed by the combined rayon industries of the South, as well as approximately 65,000 tons of sulfite wood pulp, 145,000 tons of 50° Be sulfuric acid and 105,000 tons of caustic soda. All necessary materials are produced in close proximity to the rayon plants. Over one half of the rayon made in the United States is manufactured in the South, specifically in Tennessee, Virginia, North Carolina and Georgia.

PAPER

The paper industry in the South can be traced back to 1744, when a plant existed in Virginia. North Carolina had a mill at Salem in 1766. South Carolina, Tennessee and Kentucky were locations of paper-making establishments about the same time. These small establishments, however, used only certain small amounts of hard woods.

Within the last ten years research developments have shown it possible that a very satisfactory kraft paper may be made from the very widely distributed long-leaf Southern pine. Within this period operations were developed which lead the way to approximately 13 per cent. of the consumption of pulp wood in the country being produced in the South yearly. Kraft paper is made in great quantity in Florida, Louisiana and Alabama for bagging, wrapping papers and many miscellaneous uses. The heavy brown, resinous character of this pinewood pulp renders it unfit for the manufacture of white newsprint. Methods are now in process of trial which are expected to bleach out the undesirable color, and it may be that we soon may expect to read our daily Southern newspapers printed on bleached pulp from the Southern long-leaf pine. Not only does the low cost of these long-leaf pine pulps present an attractive possibility for Southern industry, but considering the fact that rapid all-year growth permits reforestation to continue at a rate more rapid than wood consumption demands, a continuous cycle of production of raw material in excess of requirements is insured. Permanent industrial operation may follow dependent only upon demand for finished product.

COTTONSEED

The cotton crop of the United States for 1928, expressed in units of 500 pound gross weight, amounted to 14,477,000 bales, the total cottonseed produced being 6,435,000 tons. Twenty years ago this enormous tonnage of seed would have been largely discarded, but in 1928, 5,061,000 tons of cottonseed were put through refining processes which produced materials worth $200,000,000.

Research discovered that the lowly cottonseed may be split up into three components—linters, hulls and inner kernels. From the linters processes have been developed for manufacturing rayon, absorbent cotton, twine, rope, artificial leather, lacquers, celluloid, photographic films, varnishes, pyroxylin, carpets, writing paper, artificial felts, guncotton and other similar products.

From the hulls of the cotton seed are produced cattle feeds, paper in a variety of forms, stuffing material for upholstery, adhesives, fertilizer, potash, xylose and numerous other analogous materials.

From the kernels or "meats" of the seed, products are now available which we now see and consume as though they were always existent. Salad oils, lard compounds, emulsions for medical purposes, cosmetics, soaps, cattle feeds, flour for bread, cake and crackers, sardine packing oils, stearic acid for candles, washing powders, roofing tars, insulating materials, cotton rubber and compositions for phonograph records. To these many products industrial research workers are adding new and more spectacular achievements each day. Only recently we are advised by authorities that there is protein enough in a 16,000,000 bale cotton crop to furnish all the protein food requirements for 53,000,000 people for a year.

Fertilizers

In the field of fertilizers the South with the aid of research now enjoys a peculiarly enviable position, for the abundant supply of a great variety of materials are applicable to fertilizer manufacture. As an agricultural territory it is important that there is to be found large quantities of by-product sulfuric acid, phosphate deposits, a nitrogen fixation industry, considerable potash resources and raw materials for the manufacture of organic ammoniates.

Research has presented the South with an abundant supply of phosphoric acid and phosphoric acid salts. Even the Southern steel industry has deviated sufficiently from its primary purpose to supply in its basic open hearth slag a material of high phosphate availability to plant life. Nitrogen fixation plants in Virginia have joined hands with coke oven ammonia to supply large quantities of combined nitrogen. For potash to be obtained within the boundaries of the South here exist the possibilities of extraction of Georgia shales, recovery from certain industrial wastes or isolation as a by-product of cane molasses.

Within recent months we have been advised of another attainment of industrial research—the production of a fertilizer of 68 per cent. richness in plant foods—which commercial production was accomplished through the successful chemical engineering feat of the coprecipitation of the three constituents, phosphates, potash and nitrates in one homogeneous, granular product.

Scientific investigations have revealed the chemical characters of many of the Southern soils, and from these investigations steps have been taken to provide the lacking elements. Certain notable researches were performed in connection with soils found to be lacking in lime and magnesia and with the soils of the Florida Everglades which were found to be markedly benefited by additions of copper salts. Mention has already been made of the use of by-products of the cottonseed as fertilizing material.

Naval Stores

Approximately 300,000 people in the South are dependent upon the production of rosin, turpentine, pine oil, tar and pitches from the pine tree. Attributable to many varied researches the by-products of the Southern pine are now finding their way into such finished materials as soap, varnish, paper size, printing inks, linoleum, insulation materials and synthetic camphor. The raw products themselves have a market value of $70,000,000 annually. Yet the possible utilities of these raw materials of the Southern pine forests are but slightly developed.

Tung Oil

For years China has exported annually 100,000,000 pounds of tung oil into the United States for use in the paint and varnish industry. This oil is produced by tung oil trees, whose dried and hulled nuts are crushed to yield a neutral oil. From investigations of soils and climate in sections of Florida as to suitability for growth of tung oil trees, satisfactory conditions were found, and to-day over 560,000 trees are producing tung oil of satisfactory quality. Some 5,500 acres of land is thus being profitably utilized in the cultivation of trees whose fruits are yielding relatively high oil content. An American tung oil industry is thus in its infancy.

Blast-Furnace Slag

The blast-furnaces of Alabama, located principally in the Birmingham district, produce pig iron at the rate of 2,700,000 tons annually, a large percentage of which is basic iron, which is later made into steel. The iron ores of Alabama, which are smelted to produce the pig iron, are not as concentrated as are the ores of Northern furnaces and hence there is produced approximately 1,800 pounds of slag for each long ton of pig iron made. Some 2,300,000 tons of blast-furnace slag, therefore, are available from the furnaces of the district annually. Fifteen years ago this slag was cast off as a waste material, but to-day a large portion of this tonnage is converted to profitable use either as a basis for slag cement or as aggregates for cement or bituminous concrete.

The only blast-furnace slag cements of the country

are being made at this time in the Birmingham district. These puzzolan products utilize not only the water-granulated slag of the blast-furnace but hydrated lime from the lime industry of the South.

Slag from the blast-furnaces is cooled in huge graded pits, mined, crushed and graded for use as aggregates. Five hundred miles of Southern roadways are made of Alabama slag and Portland cement. Forty-five hundred miles of Southern roadways are constructed of Alabama slag and bituminous binders. Numerous buildings are made of slag concrete. Practical and scientific research both in the South and North have converted this once undesirable material from a waste to a useful raw material.

These are but a few of the prominent instances where scientific research has aided in the industrial development of the South. To these may have been added mention of many interesting discoveries in the fields of cotton textiles, cotton dyeing, tobaccos, cultivation and preservation of fruits, ceramics, soils, insecticides, petroleum refining, the production of diphenyl, production of helium, the manufacture of aluminium oxide, the production of celotex, the recovery of xylose and many other investigations pertinent to the industrial field.

For the most part these advancements have been largely responsible for industrial chemical research. In the solution of these problems industrial chemistry has been prominently aided and encouraged by geological researches and developments in chemical, electrical and mechanical engineering, so that the sum total accomplishments have not in many cases been attributable solely to the application of any one of the sciences.

To speak of accomplishments of research in the field of industrial development without enumerating some of the important scientific findings contributed from sources usually recognized as being independent of industrial activity would be to neglect paying tribute to many fine attainments.

We were permitted the pleasure one year ago of listening to an accurate account of the South's contribution to the sciences of botany, zoology, medicine, anatomy, surgery, pharmacology, pathology and several other of the sciences. In each of these fields distinct offerings have been made by Southerners. Investigations on the mechanism of heredity, on twins and twinning, oyster culture and mussels, coral formations, absorption spectra of solutions, viscosities of solvents, muscular discoveries, nervous system investigations, the transmission and control of yellow fever, surgical anesthesia, physiological behavior of poisonous alkaloids, ptomaines and cellular toxins and certain researches in connection with epilepsy and its relation to pellagra—these and many other important investigations have been contributed by Southern workers.

In the field of physical research we have to acclaim the attainment in connection with the recent discovery of two of the hitherto undetected members of the much discussed chemical family elements. Through the development of a magneto-optic method of chemical analysis exceptionally fine traces of elements have been made possible of identification and measurement, in concentration even as small as one part in 10^{11}. While academic interest in this accomplishment has centered considerably upon the discovery of the elements "Alabamium" and "Virginium" much promise is to be attached to this magneto-optic method of analysis as an effective tool of quantitative estimation.

To mention, however briefly, the many problems, industrial and academic, which are undergoing scientific investigation in the South at the present time, would be impossible. Likewise to set out the various influences which have stimulated the wide application of technical research in its various forms would be considerably complicated. Suffice it to state that the agricultural and industrial South has not only profited greatly by the relatively small number of contributions it has made to scientific discovery, but it stands to reap much greater benefits from its research conquests of the future. May the splendid accomplishments of the last fifty years serve as an ever accelerating stimulus to finer academic and industrial attainments to the end that in all the fields of science she may currently come to contribute her proportionate share of fruits of scientific research.

THE EARLY DAYS OF THE AMERICAN PHYSIOLOGICAL SOCIETY[1]

By Dr. HENRY H. DONALDSON

WISTAR INSTITUTE OF ANATOMY

As a survivor of the prehistoric period of physiology in the United States, I am asked to speak on the early days of the Physiological Society. Like all such survivors, I find myself in the position of the lady who, after the surgeons had finished with her, reported that she had only lungs and reminiscences

[1] Address at the dinner of the Federation of Societies for Experimental Biology, Philadelphia, April 29, 1932.

left. But in my own case even the reminiscences are fragmentary. Our chairman should have given me notice of this event some 45 years ago, so that I might have been better prepared. Let me sketch the background.

In the eighties the teaching of medicine, with which physiology was mainly associated, was poorly developed. I entered the College of Physicians and Surgeons in New York in 1880. It was then a proprietary school. You paid your fee and were enrolled. You could get your degree in two years by attending endless lectures and taking quizzes with a preceptor. There was a dissecting room—but no laboratories. Dalton held the chair of physiology. He was lucid in his presentation, largely based on French work—for he had been trained in Paris. An exposed heart is the only demonstration I recall.

But something unusual did happen that year. Prudden, who had been abroad with Welch, returned and offered a course in histology. It was given in a deserted ice-cream saloon, during the lunch hour, and with microscopes—mostly French models—which Prudden had borrowed from his friends. There half a dozen of us had a most inspiring introduction to histology. It was the one bright spot in the year.

In 1881 I went to Baltimore to be with Martin, the young professor of biology at the Johns Hopkins University. At that time there were no special societies dealing with biology in any of its aspects—but in 1884 Sam Clarke, then at Williams—and who had been with Brooks in Baltimore—decided that he must have some means for contact with his colleagues. So at his instigation the American Society of Naturalists was formed. In a measure this was a protest against conditions existing in the natural history section of the American Association for the Advancement of Science. This section was over-diluted with non-scientific members and, further, it met in midsummer. The Naturalists met at Christmas time.

At first all the natural sciences were represented in the Naturalists. Soon fission began. The Geologists withdrew—next the Physiologists—then other groups, and so the parent society of Naturalists kept on budding until it was reduced to something like a nucleus without cytoplasm.

Our interest lies in the event which gave rise to the Physiologists in 1887. At that time the better textbooks of physiology were that of Dalton—widely used, a pirated edition of Foster at 95 cents—and Hermann's Handbook, of which there was, I think, only one copy in the country. But physiology was in the act of declaring its independence, and the names of its representatives that occur to me are Bowditch in Boston; Chittenden in New Haven; Dalton and Curtiss in New York; Weir Mitchell, Chapman, Brubacker and Reichert in Philadelphia; and Martin, Sewall and Howell in Baltimore.

It was, I believe, at the suggestion of Weir Mitchell that a Physiological Society was formed, and the organization meeting was in 1887. During the first ten years Weir Mitchell, Bowditch and Chittenden were the presidents. There were some 15 to 20 of us, and the sessions were short.

The isolation of the mammalian heart, which is credited to Martin, served as the starting point for a number of investigations from Baltimore. There were studies in the early phases of biological chemistry by Chittenden, and Bowditch was working with the plethysmograph. At one of the early meetings we were gathered in Bowditch's new laboratory—a great room two stories high. Half way up the walls a balcony ran all around, and from this innumerable wires were strung across. Physiology was mainly in the mechanical phase of its development. Bowditch, who was a clever mechanician, had, as demonstration, a cat with plethysmographs on each of its four legs. Each of these was so arranged as to give typed records of the changes in each limb, with a corresponding graph.

It was a remarkable set-up, and the graphs were strikingly smooth—yet now and then a disturbing deviation appeared. Some one said to Bowditch, "What do the irregularities mean?" To which Bowditch replied, 'Oh, that's due to the animal"—adding with a twinkle, "But we are trying to arrange it so as to dispense with the cat."

Such were the activities of the Physiologists in the middle eighties. They looked forward to the future with both hope and confidence—but to the men of that time a meeting like this present one would be, and is, astounding.

Specialization after specialization has followed with the years—but our views concerning such have improved. I recall that a delinquent member of the Physiologists met a couple of us on the train as we were returning from a meeting, and remarked, "I've been up in Cambridge talking with some literary chaps, but I suppose that wouldn't have any interest for you fellows." Thank heaven, that attitude of the specialist is fast disappearing, and being replaced by the better notion that a specialty is merely one point on which all worth-while knowledge can be focused.

By reason of this subdivision of interest, we are ever threatened by that tidal wave of literature that sweeps down on us from year to year—but the present efforts to synthesize our knowledge, if vigorously pushed, may furnish a protection, and save us from the predicament of one of Wellington's staff. This

officer had held forth in great detail. "Sir," said the Iron Duke, "your information is too great for your understanding"—a cogent comment.

One word in closing: Martin brought to us the concept of biology, and the idea of special laboratories for physiology. The event has had far-reaching effects. It led to the founding of the Physiological Society and is the reason why, to-day, we are a Federation of Societies for Experimental Biology—ever expanding.

SCIENTIFIC EVENTS

THE SEVENTY-FIFTH ANNIVERSARY OF THE OLD SOUTH KENSINGTON MUSEUM

THIS year is the seventy-fifth anniversary of the opening of the old South Kensington Museum, and arrangements are being made, according to the London *Times*, in the Science Museum, which contains many of the original objects assembled in 1857, for a comparative exhibition illustrating the development which has since taken place in inventions. The original South Kensington Museum (in which the nucleus of the present Victoria and Albert Museum was also included) was founded as a result of the second report of the Royal Commissioners of the Exhibition of 1851.

The entrance hall of the present Science Museum and Gallery I, which adjoins it, were being cleared during the week-end in preparation for the anniversary exhibition, which will be open to the public on July 2. The exhibition will select the terminal points in a few branches of science which were at a primitive stage during the fifties and sixties. A model of an omnibus of the 1850's and locomotive models of the next decade will be placed beside models of a modern London omnibus and of one of the latest L. M. S. locomotives.

In many of the galleries upstairs parts of the permanent exhibition will be rearranged and relabeled for the anniversary, and a space has already been cleared in the Chemistry Gallery for illustrating the range of colors and fabrics now available to the artificial dye industry. Some of the largest British firms of chemists and textile manufacturers are lending exhibits for this portion of the exhibition. It is also intended to illustrate the part taken by the 1851 commissioners in founding the museum and fostering it since that time. The Great Exhibition in Hyde Park, and the development of the site south of the Park into the Museum and College area of South Kensington will be seen in a series of water-colors and plans.

The experimental apparatus used at University College, Gower-street, by the late Sir William Ramsay, has been transferred on indefinite loan from the college to the Science Museum, where it is now partly arranged for view. The exhibits now to be seen include the blow-pipe with which Ramsay himself made most of the apparatus connected with his discoveries of rare gases.

Some new additions have also been made to the ship-model collection in the museum. A model of a Handley Page "Hannibal" type air liner has been presented by Imperial Airways, while the Sudan Government have given a primitive smith's forge of the type used at the present time by the natives of the Jur tribe, and used with some variations in Ancient Egypt some 35 centuries ago.

The museum workshops have reconstructed a Roman pertica, or 10 ft. measuring rod. A series of the metal caps and ends of such surveyors' rods were discovered at Pompeii in 1912 by Cav. M. Della Corte, and replicas of these have been used in the museum.

SMITHSONIAN EXPEDITIONS

TWENTY-FIVE scientific expeditions were sent out by the Smithsonian Institution during the past year. They are described in detail in the annual Smithsonian exploration reports recently issued for distribution.

A. F. Moore, of the staff of the Smithsonian Astrophysical Observatory, spent months on barren peaks of African mountains in futile search for a satisfactory Old World site for a solar radiation station. He sought a high desert altitude with, so far as possible, a cloudless, dustless atmosphere. For more than a month he made daily observations on a high peak on Fogo Island in the Cape Verde group. Although generally cloudless, this mountain proved to be surmounted nearly all the time by a high, thick blanket of haze which seems to rise from the Sahara desert.

Disappointed here, Mr. Moore went on to Southwest Africa where, sometimes for weeks at a time, he conducted observations on four mountain peaks and made an unsuccessful effort to scale a fifth. None proved entirely satisfactory.

More than 600 specimens of fossil animals, mostly fragmentary, were collected under the direction of Dr. Charles W. Gilmore in Montana and Wyoming. It is anticipated that many new forms of animal life will be revealed when a systematic study is made. Material of interest included a partial skeleton of a large, flesh-eating mammal, the pachyaena; three partial skeletons of the coryphodon, a rhinoceros-like animal, and six more or less complete skulls of ancient crocodiles. More than 2,500 fossil specimens were se-

cured in Devonian-age deposits in eastern New York by G. Arthur Cooper, of the Smithsonian division of invertebrate paleontology. Most of these were recovered from the numerous ravines and quarries around Cazenovia, Morrisville, and Hamilton, N. Y. The majority of the entombed animals are invertebrates, including nearly 150 species of ancient clams.

Dr. Alexander Wetmore, assistant secretary of the institution, hunted rare birds in dense rain forest and on high mountains in Haiti. Following an airplane reconnaissance of the little known La Hotte Mountains, which required little more than three hours, Dr. Wetmore and his party set out to reach this region with a pack train. At the end of six days of almost constant rain, over trails whose steepness and badness beggars description, they reached a point where the pack animals could go no further and they were obliged to proceed with a train of porters. The party pitched camp at an elevation of 4,200 feet and, drenched with incessant rain, climbed to the highest peak of the La Hotte range. They found a very abundant bird life and made a large collection for the United States National Museum. The party then proceeded to the Dominican Republic. Among the birds collected on the island of Beata off the Dominican coast was a hitherto unknown variety of wood warbler.

Dr. William M. Mann, director of the National Zoological Park, collected wild animals in British Guiana. Dr. Mann was seeking especially for reptiles. Among his captives was a small, brilliant red and black burrowing snake related to the boas which probably was the first of its kind to come alive into any collection. Another curious captive was a "jumping johnnie," a small snake with the under side of its tail colored a brilliant red. When picked up it goes through the motions of stinging with this tail, hitting the hand that holds it again and again with the brilliant red tip. It is harmless. Dr. Mann collected in all 350 live specimens, some representing varieties seldom seen in captivity. There were 128 birds, 21 mammals and 189 reptiles.

Dr. Paul Bartsch, curator of mollusks, continued his biological explorations in the Tortugas. He reports one interesting observation on the ability of birds to adjust themselves to a change in environment. On one "key" he found that all the trees, bushes and shrubs had been swept away by hurricanes. Great numbers of noddy terns used to build their nests in the vegetation. He found that now all have changed to a ground dwelling habit. Still retaining the desire to make nests they gather bits of dead twigs and shape them into semblances of nests on the ground. The birds, Dr. Bartsch said, seem to have a decided "lingo-tactic sense," for old boards seem to satisfy their desire for wooden homes. Birds were found incubating their eggs upon bare boards.

GEOLOGY, PHYSIOGRAPHY AND ECOLOGY AT THE PULLMAN MEETING OF THE PACIFIC DIVISION OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

FOR those interested in the geology, physiography or special problems of ecology of the "Inland Empire" of the Pacific Northwest, a rare feast is spread for the Pacific Division of the American Association for the Advancement of Science, meeting in Pullman, Washington, from June 15 to 18. On the general program, Dr. J Harlen Bretz, of Chicago University, will speak on his investigations of the scablands of the Columbia Plateau and will conduct a party to the field to study at first hand this unique problem of Pleistocene erosion. The Palouse Hills in which Pullman is situated, in themselves, present an inviting study as to their genesis, and will be a revelation to all comers who have not seen approaching harvest in the wheat fields which cover them. The farm and laboratory of the new U. S. Station for Erosion Control will be suggestive of what the immediate future may have in store in moisture control for agriculture. Several short local excursions are planned and two more extended ones, in addition to that with Dr. Bretz, will attract to more distant points of interest. One of these will be a boat excursion up the canyon of the Snake River from Lewiston, Idaho, to a point where the depth of the gorge, approximately 6,000 feet, rivals that of the Grand Canyon of the Colorado. Those who have made this boat trip describe it as unforgettable. Perhaps most delightful of all, because less hurried and inviting leisurely travel and prolonged stay, will be the excursion to the almost wholly unknown Wallowa Mountains of northeastern Oregon, and the new Eagle Cap Primitive Area in these highlands. A hasty survey[1] of this region in the summer of 1931, together with Professor Warren D. Smith's very readable account,[2] have given the writer the impression of a dome-like uplift of late Miocene time which carried Columbia basalts almost to its crest at an original elevation of between ten and twelve thousand feet. At the northeastern side this dome gave way in a great down fault of about thirty miles' length with a scarp of about 4,000 feet above the plain (Wallowa Valley). A Pleistocene ice-cap formed about Eagle Cap Mountain and no less than five glaciers carved deep gorges down to the

[1] Observations here recorded were made possible by a grant for research in this region by the Research Committee of the National Society of Sigma Xi.

[2] Warren D. Smith, "Wallowa Mountains and County," Commonwealth Review of University of Oregon, January, 1928.

level of the plain on northern and eastern sides of the dome. These are the canyons of Lostine River, Hurricane Creek, Wallowa River, Big Sheep Creek (perhaps) and Imnaha River. The alpine sculpture is magnificent. To the physiographer, the unusually perfect state of preservation of the moraine which encloses Wallowa Lake is most impressive. The lateral moraines reach a height of 700 feet above the water level of the lake and the steepness of the inner slope is quite unbelievable. Professor Smith finds the outer slope records five advances of the ice. Only at the outlet of the lake is any part of the moraine disturbed since the recession of the ice.

To the ecologist this oasis in the midst of semi-desert (Upper Sonoran), with lush temperate vegetation in lower valleys, extending upward to alpine, is a paradise for exploration.

As mountaineering goes, one reaches all these charming possibilities with absurd ease from the friendly little agricultural villages of Enterprise, Joseph, Lostine and Wallowa. The car is parked at the end of a good forest road two thirds of the distance between the entrance of the mountain valley and the base of Eagle Cap. Nine miles of good foot or horse trail reaches the lake basin at about 8,000 feet elevation and surrounding peaks reach about 9,800.

THOMAS LARGE

SPOKANE, WASHINGTON

THE SCHOOL OF ENGINEERING OF YALE UNIVERSITY

THE Yale Corporation has authorized the existing division of engineering to assume the status of a school with the title of the Yale School of Engineering. The school will include the functions and activities in civil engineering (including drawing), chemical, electrical and mechanical engineering, metallurgy and engineering mechanics.

This organization is the result of a proposal made by a committee which for over a year has been studying the teaching of science and engineering at the university. It has long been desired by the departments of engineering, and the recommendation has the approval of the Board of Permanent Officers of the Sheffield Scientific School.

Dean Charles H. Warren, of the Sheffield Scientific School, in explaining the organization of the Engineering School, said in part:

> Previous to 1919 all instruction at Yale in engineering was given in the Sheffield Scientific School. After the reorganization of the university in that year undergraduate instruction in engineering remained in the Scientific School, but the graduate work was transferred to the Graduate School.
>
> Believing that engineering work of all grades, together with research and other activities in the engineering departments, constitutes a distinctive unit within the university requiring a unified control for its administration and the satisfactory coordination of its parts, the Division of Engineering, which includes the several engineering departments, has for some years performed what are virtually the functions of a faculty of engineering. Their recommendations have, however, been subject to the approval of the boards of the Scientific School and the Graduate School, respectively, and the activities of the engineering departments have in general been under the dual control.
>
> While this arrangement has worked reasonably well, it is from the administrative point of view needlessly cumbersome, and furthermore it has been felt by the engineers that the interests of engineering would be advanced more rapidly if the engineering departments were given the status of a school of engineering under its own dean and board of permanent officers, a form of organization which has long since been followed by every other university in the country.
>
> Under this new arrangement all students of engineering will from now on be under the jurisdiction of an engineering faculty, and the engineering degrees will be conferred upon its recommendation. This change will not, however, modify in any essential particular the general conduct of the instructional work, nor the other activities of the engineering departments. Undergraduate students will be admitted, as in the past, to the freshman year and from it will enter the undergraduate department of the engineering school. Their relations with other undergraduates, and in regard to all social and extra-curricular activities, will remain exactly as at present.

SCIENTIFIC NOTES AND NEWS

A DINNER in honor of Dr. Ernest W. Brown, Gibbs professor of mathematics at Yale University, who becomes professor emeritus at the end of the academic year, was held at the New Haven Lawn Club on May 24. The dinner was given by members of the three university departments with which Professor Brown has been associated: astronomy, mathematics and physics. Dean Clarence W. Mendell was toastmaster. Addresses were given by Dr. Frank Schlesinger, director of the University Observatory; Professor Oystein Ore, director of graduate studies in mathematics; Governor Wilbur Cross, dean emeritus of the Graduate School, and President James Rowland Angell.

THE degree of honorary doctor of veterinary medicine was conferred upon Dr. Theobald Smith, of the Rockefeller Institute for Medical Research, by the

University of Giessen at the hundredth anniversary of the granting of veterinary degrees.

AT the sixty-ninth commencement of the University of California, the degree of doctor of laws was conferred on Dr. Joseph Erlanger, professor of physiology in the Washington University (St. Louis) School of Medicine.

THE honorary degree of doctor of science was conferred upon Dr. Karl T. Compton, president of the Massachusetts Institute of Technology, on the occasion of the thirty-third commencement of Clarkson College, Potsdam, New York. Dr. Compton made the principal address.

ACADIA UNIVERSITY, Wolfville, Nova Scotia, at its ninety-fourth commencement, conferred the honorary doctorate of science on Laurie D. Cox, professor of landscape engineering at the New York State College of Forestry, Syracuse, and the honorary degree of doctor in civil law on Merritt Lyndon Fernald, Fisher professor of natural history in Harvard University.

AT the commencement exercises of the Worcester Polytechnic Institute on June 17, the honorary degree of doctor of engineering will be conferred on four graduates of the college. They are: Leon P. Alford, vice-president of the Ronald Press Company, New York; John J. Donovan, vice-president of the Bloedel-Donovan Lumber Mills; Alfred D. Flinn, director of the Engineering Foundation, New York, and George W. Patterson, powder expert at the Naval Powder Factory. Mr. Donovan will deliver the commencement address.

HONORARY degrees conferred by Columbia University at commencement included the doctorate of science on Dr. Dugald C. Jackson, professor of electric power production and distribution at the Massachusetts Institute of Technology. The citation by President Butler read: "Dugald Caleb Jackson, professor in the Massachusetts Institute of Technology, native of Pennsylvania, and trained at Pennsylvania State College and at Cornell University; closely uniting industrial experience with scientific research, and, after sixteen years of service at the University of Wisconsin, passing a quarter-century ago to the department of electrical engineering at the Massachusetts Institute of Technology, active in a score of ways as engineer, as educator and as administrator; honored at home and abroad for distinction of mind and of service marked by broad vision, boundless energy and vigorous leadership; a true ornament of our country's scientific endeavor and of its educational force."

THE Roosevelt medal for distinguished service has been awarded to Dr. Robert A. Millikan and will be presented to him at a dinner to be given on the seventy-fourth anniversary of President Roosevelt's birthday, on the evening of October 27. Heretofore since the establishment of the medal in 1923 three awards have been made annually. In a statement announcing the single award this year, Dr. James R. Garfield, president of the Roosevelt Memorial Association, said: "Dr. Millikan combines in a striking degree the qualities of a scientist, an administrator, a teacher, a philosopher and public servant. He has been conspicuous in the movement of scientific speculation away from the materialistic and mechanistic theories of the nineteenth century toward spiritual conceptions in harmony with the aspirations of religion."

THE Lamme medals of the Ohio State University, for "meritorious achievements in engineering and the technical arts," will be presented to Albert V. Bleininger, chemist to the Homer Laughlin China Company, and to Ralph D. Mershon, consulting engineer and chemist, New York, at the fifty-fifth commencement on June 13.

PROFESSOR DOUGLAS JOHNSON, of Columbia University, has been elected a corresponding member of the Geological Society of Belgium.

THE Jacksonian Prize for 1931 of the Royal College of Surgeons has been awarded to J. Paterson Ross, of St. Bartholomew's Hospital, for his essay on the surgery of the sympathetic nervous system. A certificate of honorable mention for an essay on the same subject was granted to Lambert Charles Rogers, of the Royal Infirmary, Cardiff.

PROFESSOR GIUSEPPE PIANESE, professor of anatomy and pathological histology at the University of Naples, was recently appointed an academician of Italy.

DR. ROBERT A. MILLIKAN, of the California Institute of Technology, was reelected president of the board of directors of the National Advisory Council on Radio in Education at the second annual assembly in Buffalo, New York, held from May 18 to 20. Other officers reelected were: *vice-presidents,* Livingston Farrand, Meta Glass, Robert M. Hutchins, Michael I. Pupin, Walter Dill Scott; *chairman of the board,* Norman H. Davis; *vice-chairman,* William J. Donovan; *treasurer,* Ralph Hayes; *secretary and director,* Levering Tyson.

THE Botanical Society of New Orleans has elected the following officers for the year 1932–33: Dr. L. J. Pessin, associate ecologist, Southern Forest Experiment Station, *president;* Miss Anna Haas, *vice-president;* Philip C. Wakeley, associate silviculturist, Southern Forest Experiment Station, *secretary,* and Paul V. Siggers, Bureau of Plant Industry, *treasurer.*

At the annual dinner of the society on May 10, Dr. Miriam L. Bomhard, assistant professor of biology at Newcomb College, spoke on "Palms in New Orleans."

HENRY HARRISON HENLINE, assistant national secretary of the American Institute of Electrical Engineers since 1927, has been appointed acting national secretary of the institute. Mr. Henline was appointed to fill the vacancy created by the death in February of F. L. Hutchinson who had been national secretary for twenty years.

PROFESSOR LEON B. RICHARDSON, of the department of chemistry of Dartmouth College, has succeeded Professor W. S. Messer as president of the college chapter of the American Association of University Professors.

DR. MORRIS SCHERAGO, head of the department of bacteriology at the University of Kentucky, has been elected an associate member of the American Society of Clinical Pathologists.

DR. GEORGE S. BEL, emeritus professor of theory and practice of medicine and clinical medicine, Tulane University of Louisiana School of Medicine, New Orleans, has been appointed professor of the principles and practice of medicine in Louisiana State University Medical Center, succeeding the late Dr. James Birney Guthrie.

THE department of zoology at the University of Minnesota announces the appointment of Dr. Clarence P. Oliver as assistant professor of zoology. Dr. Oliver will give the courses in genetics.

DR. ROBERT F. MEHL, assistant director of research for the American Rolling Mill Company, Middletown, Ohio, has been appointed as director of the bureau of metallurgical research at the Carnegie Institute of Technology. Under his direction and through a grant from the Carnegie Corporation the work of the laboratory will be extended.

DR. F. B. MUMFORD, dean of the University of Missouri and director of the Agricultural Experiment Station, has returned from six months' absence in European countries, where he made a study of agricultural education and research, and of what governments are doing to aid agriculture. Dr. A. E. Murneek, associate professor of horticulture, has returned from a similar absence spent in studying the work being done by institutions in eastern and central Europe and in Russia in the field of plant physiology.

DR. GEORGE DOCK, Pasadena, California, formerly head of the department of medicine at the University of Michigan, will be this month the honor guest of the 1907 medical class at its twenty-fifth reunion. Dr. Dock will give a medical clinic at the University Hospital on June 18, to which former students and alumni are invited.

DR. HENRY J. GERSTENBERGER, professor of pediatrics in the School of Medicine of Western Reserve University, gave on May 24 the annual address before the Case Chapter of the Society of the Sigma Xi. His subject was "Studies in Human Rickets."

DR. W. F. G. SWANN, of the Bartol Research Foundation; Dr. Saul Dushman, of the General Electric Company; Professor Debye, of the University of Leipzig, and Professor Charles A. Kraus, of Brown University, are the special lecturers this summer in the department of physics of the Ohio State University. In the issue of SCIENCE for May 27, it was stated erroneously that the lectures were to be given at the University of Illinois.

A GRANT of $250.00 from the Committee of Scientific Research of the American Medical Association has been made to the department of physiology of the University of Cincinnati to further the work of Dr. Esther Bogen Tietz on pseudo-pregnancy in rabbits.

THE University of Maryland celebrated the one hundred and twenty-fifth anniversary of its founding on June 3. The exercises were held in Baltimore and at College Park. Speakers included Dr. William H. Welch, director emeritus, of the Johns Hopkins University Institute of the History of Medicine, and John H. Finley, associate editor of *The New York Times*.

WE learn from *Nature* that the Fifth International Congress of Scientific Management will be held at the Koloniaal Instituut, Amsterdam, from July 18 to 23. The subjects to be discussed include costing, markets, technical and mental education of foremen for rationalization, systems of promotion, rationalization as a part of education, costs of retail distribution, agricultural labor and rationalization in various types of industry. Papers from many countries have been contributed through the national associations or committees and are being published in two volumes in advance of the meeting; summaries only will be read at the sessions of the congress. Excursions in Amsterdam, to Eindhoven, the Zuider Zee and to Rotterdam are being arranged, and continental railways are giving special facilities for those attending the congress. The general secretary for the congress is Mr. V. W. van Gogh, Herrengracht 209, Amsterdam.

AT the House of the Royal Society of Medicine on May 19, Sir Charles Sherrington, the recent Hughlings Jackson lecturer, was presented with the Hughlings Jackson gold medal together with an honorarium of 100 guineas. The presentation was made by Dr. T. Watts Eden, president of the Royal Society of

Medicine. The London *Times* recalls that the Hughlings Jackson lecture was founded in 1897 to honor Dr. Hughlings Jackson, and in recognition of his service to humanity by his work on the functions of the nervous system. For some time it has been felt that so important a commemoration lecture should not go unendowed. Subscriptions for an endowment were invited from neurologists all over the world, and with the money raised the Hughlings Jackson lecturers will receive a gold medal and an honorarium of 100 guineas. Sir Charles Sherrington is the first lecturer to receive the medal and honorarium. He also receives the diploma of honorary membership of the Section of Neurology of the Royal Society of Medicine. After the presentation Sir James Crichton-Browne gave personal reminiscences of Dr. Hughlings Jackson, and Mr. Leslie Paton (chairman of the Fund Committee) presented Dr. Watts Eden with two silver replicas of the medal for the Royal Society of Medicine. The design for the gold medal is the work of Mr. Percy Metcalfe, and the dies have been prepared by the Royal Mint.

A CORRESPONDENT writes: "The Brooklyn Botanic Garden has recently inaugurated a feature which is probably unique for botanic gardens, and possibly unique in the way of geological education. This consists in placing on about twenty-eight boulders in the Botanic Garden small bronze tablets, giving the composition of the boulder, the geological age to which it belongs, stating that it was transported to the Botanic Garden by the continental ice sheet during the Ice Age, and giving approximate location of the rock ledge from which the boulder was dislodged. In connection with these labels, the Botanic Garden has edited a "Guide to Our Boulders; Geological History of the Brooklyn Botanic Garden." This appears as the May issue of the Brooklyn Botanic Garden *Record*. The principal part of the guide is written by Dr. Ernst Antevs—one of the leading authorities on certain aspects of glacial geology. It is richly illustrated with maps and views."

Nature states that Sir Frank Dyson, Astronomer Royal, opened the new Mond photographic equatorial and dome at the Norman Lockyer Observatory, Salcombe Regis, Sidmouth, on May 28. The Norman Lockyer Observatory is the only astronomical observatory in Great Britain founded and maintained by a private corporation under the Companies (Consolidation) Act of 1908. Since it was started, nearly twenty years ago, it has been equipped and maintained entirely by private donations. The equipment includes two twin telescopes, one with a 10 in. object glass and a 12 in. prismatic camera, and the other with a 10 in. object glass and a 9 in. prismatic camera for photographing the spectra of stars and other celestial bodies. A very large collection of such photographs, numbering 6,500, has already been taken at the observatory, affording valuable records of the nature and movements of objects in the stellar universe. Dr. Robert Mond, who has been a generous supporter of the observatory since it was founded, has now presented a unique photographic equatorial, with a separate building and dome to house it. The instrument consists of a battery of four cameras with clock mechanism, so that it will be possible to follow automatically movements of the heavens over a wide field of the sky.

A COLLECTION of Brazilian plants, gathered about a century ago by the Scandinavian naturalists, Eugene Warming and Wilhelm Lund, has been received at the Field Museum of Natural History from the University Museum of Copenhagen, Denmark.

SEVERAL members of the committee on fuels and lubricants of the American Society of Agricultural Engineers, of which R. B. Gray, chief of the division of mechanical equipment of the Bureau of Agricultural Engineering, of the U. S. Department of Agriculture, is chairman, recently visited a number of tractor and engine manufacturers in the Central West with a view to improving the performance and efficiency of tractors and engines.

A 50,000-ACRE national-forest tract in Montana has been set aside by the Forest Service as a "primitive area." The area, on the Gallatin-Madison County line in the Gallatin National Forest, abounds in flowers, trout and game, and includes the Spanish Peaks mountain group, widely known for its scenic grandeur, and about twenty beautiful, small alpine lakes. It is to be known as the Spanish Peaks Primitive Area.

CHINSEGUT HILL, a 2,082-acre tract in Hernando County, Florida, has been deeded by the owners, Colonel and Mrs. Raymond Robins, to the Department of Agriculture for use in the work of the department. The area will be used as a bird refuge; and also, in cooperation with the Florida Agricultural Experiment Station, in studies of problems relating to citrus fruits, livestock, feed and forage production and related problems. A diversity of cover and the existence of lakes and marshes lend additional value to the tract for the conservation of many species of wild life, including migratory birds. Great appreciation was expressed by Secretary Hyde and other officials of the department to Colonel and Mrs. Robins for their contribution to wild-life conservation and to the agricultural development of the South. The former owners will continue to live in the old mansion house on the area for such time as they desire.

DISCUSSION

SOLAR AND RADIO PERIODICITIES

AT the April, 1932, meeting of the National Academy of Sciences I gave a paper which has been published under the title "Periodicity in Solar Radiation," by C. G. Abbot and Gladys T. Bond (Smithsonian Misc. Coll., Vol. 87, No. 9). Dr. L. W. Austin has published "Tables of North Atlantic Radio Transmission Conditions for Long-wave Daylight Signals for the Years 1922–1930" (Proc. Radio Engineers, Vol. 20, No. 4). It occurred to Mrs. Bond and me to see whether the departures from monthly normals in radio transmission showed the seven periodicities of 7, 8, 11, 21, 25, 45 and 68 months, respectively, which occur in the variation of solar constant values. We therefore computed the monthly normals from Dr. Austin's figures, and obtained the departures of all his observed monthly radio transmission values, 1922–1930. This series we analyzed by the aid of the periodometer. We found the seven periodicities above named and one other of 18 months, all well indicated. Combined they account for all longer period radio transmission variations. On the whole, the amplitudes of the solar periods and of the radio periods run nearly parallel. The cycle of eighteen months, though not found in solar variations, is conspicuous in terrestrial temperatures, as pointed out in our paper above cited. The phase relations between solar and radio periodicities are very interesting. We hope to publish details of the investigation in the autumn, but believe that the readers of SCIENCE will be interested to know that periodicities in solar radiation seem to accompany periodicities in radio transmission.

C. G. ABBOT

REPORTS OF THE PRINCETON UNIVERSITY EXPEDITIONS TO PATAGONIA 1896–1899

THE late Mr. J. B. Hatcher, at that time curator of vertebrate paleontology in the Princeton Museum, planned these expeditions and raised the principal funds for them from the students who had been with him in his various western explorations.

The first and third of the expeditions comprised Mr. Hatcher and Mr. O. A. Peterson, now of the Carnegie Museum in Pittsburgh; and the second one, Mr. Hatcher, and Mr. Colburn, of Washington, as ornithologist.

The principal object of the expeditions was to collect the wonderful fossil mammals of the Santa Cruz formation, which had been made known to the world by the late Dr. F. Ameghino, of Buenos Aires. In this the work was eminently successful; but was so expanded as to cover a great many other fields, and very extensive collections of invertebrate fossils and of the recent mammals, birds, fishes, reptiles, freshwater shells, plants, etc., of southern South America and Tierra del Fuego were made.

It was Mr. Hatcher's idea to publish this great wealth of new material in a series devoted to those topics alone; and when this project was laid before the late Mr. J. Pierpont Morgan, he generously contributed a large sum, which was at that time estimated to be sufficient for the whole publication. The various groups of fosils and recent animals and plants were entrusted for study and report to various specialists, nearly all of whom found it necessary to demand much more text and many more plates than they had originally estimated. The additional expense over the original scheme was met by contributions from the trustees of the Carnegie Institution of Washington and of Princeton University. Planned for six quarto volumes, the series has grown to twelve such volumes with three atlases of plates.

The first part was issued in the spring of 1901; the last part, concluding Volume VII, has just appeared. Needless to say, the editor is very much gratified at being able to issue the entire work over the thirty-one years which have elapsed since the publication of Part 1.

W. B. SCOTT
Editor

PLEISTOCENE MAN IN MINNESOTA[1]

DR. FRANK LEVERETT, geologist of the U. S. Geological Survey, prepared volume number 12 of the Minnesota Geological Survey, under Director Professor William H. Emmons. The volume is entitled "Surface Formations and Agricultural Conditions of Northwestern Minnesota." It was published in 1914. On sheet 1 of the map accompanying said volume Dr. Leverett shows certain "clayey lake beds," designated "L C"—one of which in Otterteil County is now of peculiar importance. The legend on the map which describes these clayey lake beds reads, "Chiefly in low part of areas of extinct lakes where fine material found lodgement below level of wave action."

From twelve feet beneath the existing varved silt which in glacial time flowed into and filled the ancient lake in Ottertail County, a human skeleton has been recovered under controlled and documented conditions.

May 7, 1932, Drs. C. R. Stauffer, G. A. Thiel, geologists, and F. K. Butters, botanist, colleagues in the University of Minnesota, visited the site of the find and, in agreement, bear scientific testimony concerning the geological nature of the extinct lake from whose silted depths the human skeleton was rescued.

[1] A preliminary announcement.

Together the three above scientists and the writer dug out anew the spot where the skeleton was found. There we secured seven fragments still in place which are additional parts of the original fossil materials in my laboratory. We thus authenticated the exact site of the find which had fortunately been documented by a diary entry written on the spot by the road boss on the day of the discovery. Even in this preliminary announcement, I must note the cooperative and intelligent interest, in the matter of this find, of the following gentlemen connected with the Minnesota State Highway Commission, namely Messrs. C. M. Babcock, P. F. Stary, Clarence Wright and C. A. Steffen. In the face of the state program for extensive road building, we had written asking to be informed of such possible finds of ancient man as might be exposed by extensive earth cuts made during road work. The recovery, preservation and initial information of the subject of this announcement is one of the fortunate results of this state-wide cooperation.

Our extinct glacial lake had existed earlier than most of the extensive world-famous Glacial Lake Agassiz. It now seems probable that the extinct lake of our immediate interest may have been contemporaneous with an early stage of Glacial Lake Agassiz—*i.e.*, with Agassiz when it was only about 120 miles long, north and south, and only some 40 to 50 miles wide. Its eastern border was then confined by glacial ice or by the Leaf Hills Moraine (also close within which ice or moraine our lesser lake probably then existed farther to the east). At the north, Agassiz was then confined by glacial ice which, as it melted in retreat, left the Fergus Falls Moraine and the Leaf Hills Moraine on the north and northwest. Thus as early as 1895, or 37 years ago, Dr. Warren Upham had published authoritative data which will be of value in the geological dating of our Pleistocene skeleton in his book, "The Glacial Lake Agassiz," volume 25 of the United States Geological Survey. In its early phases of existence, Glacial Lake Agassiz drained southward through the present Minnesota River, starting near what is now Lake Traverse. That early outlet of Agassiz was several miles southwest of and a few hundred feet lower than the lake beneath whose ancient silt the skeleton was discovered. The varved silt bed covers points in the near-by topography at least fifty feet higher than the point where the skeleton was found and where it had originally been naturally deposited under the undisturbed varved silt. The lake had been filled with silt in the form of "rock flour" washed out from beneath the near-by glacier. The fine silt had settled seasonally in thin even layers. To-day the varves still lie horizontally just as they had been deposited in the glacial lake below the level of wave action.

The skeleton recovered is of a youth under twenty years of age. The skull is of a primitive *Homo* who, of course, must have been of an American ancestral type. The nasal aperture has distinctly simian sill and borders. There is no projecting nasal spine. The teeth are unusually large. There is a marked degree of prognathism. The sagittal suture is extremely simple. So far as reconstruction and measurements have progressed, the type of man revealed is suggestively more proto-Eskimo than proto-Indian. The body apparently had originally all been in the lake in the spot where the skeleton was so largely recovered. With exception of the bones of hands and feet, the entire body is well represented in the parts we now possess.

It is interesting also that artifacts were found with the skeleton, including a crude dagger of antler and a large pendant of shell—both of which had been attached to and worn by the youth, as each has a hole for a leash.

Complete scientific data will later be presented on this Pleistocene man—which, for purposes of identification, we name "the Minnesota man."

ALBERT ERNEST JENKS
UNIVERSITY OF MINNESOTA

THE LITERATURE OF TAXONOMY

IN a paper entitled "A New View-Point in Paleontology,"[1] Dr. E. M. Kindle outlines the difficulties which confront the paleontologist who attempts to use—or find—the scattered literature of taxonomy. As a partial remedy for the situation, he proposes the republication, upon standardized cards, of original descriptions and figures, with such supplementary material as is essential to their use. This card catalogue is to be prepared first for Devonian invertebrates of North America; upon it, fourteen or fifteen paleontologists already are working, or have agreed to work.

Being members of these fifteen, with copy for more than eight hundred cards describing sponges, stromatoporoids and sponges already in our files, we recognize the value of Dr. Kindle's suggestion. Probably it offers greater aid to working paleontologists—especially those in institutions whose libraries are small and poorly supported—than does any other he could have made.

Yet it seems to us that such a catalogue solves only present and past problems. Unless it is accompanied by a plan for future publication, also upon standardized cards, the present situation is bound to be repeated as new species and subspecies are described.

Nor does it seem enough to provide for additions to the catalogue, in the form of cards reproducing

[1] Trans. Royal Soc. Canada, 25, sec. 4: 21–27, 1931.

future source material. That would mean that the expense of publication must be borne twice: once by the journal or institution printing the author's paper, and once by the institution sponsoring the catalogue. One of these costs would be waste—and the money, if spent, should go into productive publication.

We suggest, therefore, that while efforts are being made upon the catalogue, as originally conceived by Dr. Kindle, and sponsored by the Paleontological Society, others be devoted to the problem of providing original publication, upon cards, of future original paleontologic descriptions and of significant revisionary material. This plan will demand, of course, funds for printing and for maintaining a central office where cards may be edited, published and sold; as well as international cooperation among contributing agencies and authors.

We do not minimize these problems of securing support, but the rewards to be achieved command attention. Instead of a future of widely scattered descriptions, periodically assembled and republished upon cards, the paleontologist would have those cards, bearing initial descriptions and figures, and available from a central office. Single species, instead of being buried in papers on stratigraphy, areal or economic geology, would appear upon individual cards, each under its own name and readily discoverable. Authors need not wait for the completion of long papers—nor will they resort to the almost useless "preliminary description," often published to establish priority rather than to enlighten its users. By the use of cards, one species may be published as readily as a dozen, and as readily found by other workers. The fear that a description may become "buried" will haunt neither its author nor the subsequent student, who will find the sources that he needs for study available without extended search, at a price which (if necessary) he himself can pay.

MILDRED ADAMS FENTON
CARROLL LANE FENTON

WEST LIBERTY, IOWA

AN APPEAL TO AMERICAN BIOCHEMISTS

J. L. W. THUDICHUM, pupil of Liebig, has been recognized for many years as one of the great biochemists. His splendid contributions in the field of lipoid chemistry (chemistry of brain tissue) are well known. His contributions in pigment biochemistry, not as well recognized, were also fundamental. He was the pioneer investigator of the pigments, named by him "luteins," now known as carotinoids. He also contributed outstanding papers upon the urinary pigments, bile pigments and hematoporphyrin, which he recognized as appearing in other sources besides the blood. The amino-acid "norleucin" was originally discovered by Thudichum. A number of other substances of biochemical interest began their existence as entities in the laboratory of this unusual worker, although they were rediscovered and renamed by later investigators. In the interest of science Thudichum wrote numerous texts, all replete with profound historical introductions, upon many divergent topics.

Thudichum also, somehow, found time to carry on a medical practice, using a good deal of his income to purchase platinum utensils, etc., for carrying on his researches, many of which were conducted in his private laboratory.

An interchange of communications with Dr. Otto Rosenheim (London), who for many years has been collecting data upon Thudichum's life, has brought the information that the five daughters of Thudichum are in dire financial need. The members of the American Society of Biological Chemists and others who care to do so may contribute towards a fund for them. Contributions, however small, will be highly appreciated. Checks may be mailed to Dr. David L. Drabkin, Medical School of the University of Pennsylvania, who will transmit the collected fund as a contribution of American biochemists to the parties abroad.

RUSSELL H. CHITTENDEN
PHOEBUS A. LEVENE
LAFAYETTE B. MENDEL

CONFERENCE ON ASTROPHOTOGRAPHIC PROBLEMS

A CONFERENCE on Astrophotographic Problems was held at the Harvard Observatory on March 23, on the occasion of the dedication of the new astrophotographic building. The building contains the large collection of photographic plates, the library of the observatory and many offices.

The following are abstracts of the papers presented:

The Harvard collection of astronomical photographs: ANNIE J. CANNON. The history of astronomical photography at the Harvard Observatory dates from 1850, when the first photograph of a star ever taken was made here with the 15-inch equatorial telescope. Since that time the collection of plates has grown steadily, and it now contains about 400,000 glass negatives, of sizes from 4 x 5 inches to 14 x 17 inches. The earliest plates, obtained in 1850–1852, were daguerreotypes taken under

the direction of William C. Bond, the first director of the observatory. The process was so slow that only the brightest stars would "take," and no impression could be made of the North Star, however long the exposure. The introduction of "wet" collodion plates brought new hope, and George P. Bond, the son and successor of William Bond, succeeded in 1857 in photographing by their use stars of the sixth magnitude, which includes all visible to the naked eye. About one hundred plates of this period are still in good condition. The Harvard collection forms a continuous series from 1885, when dry plates were first available. At that time Edward C. Pickering, the fourth director of the observatory, started with great zeal and enthusiasm on the large task of photographing the whole sky. The Bache fund enabled him to secure an 8-inch photographic lens which has been continually in service since that early day. With the help of Mrs. Henry Draper, of New York City, who established the Henry Draper Memorial, and of the Boyden fund for the erection of an observatory at a high altitude, four photographic telescopes were installed between 1885 and 1890, two in Cambridge and two in Peru. Up to the present time, these four telescopes have taken 142,000 plates. The results of a study of these plates include the discovery of the first spectroscopic binary; of one thousand variable stars, in globular clusters and elsewhere, and of ten novae; as well as the spectral classification of 225,000 stars, and the establishment of an international system of stellar magnitudes. In 1893, by the generous gift of $50,000 from Miss Catharine Bruce, of New York City, a 24-inch doublet was ordered by Professor Pickering from Alvan Clark and Sons, and was sent to the Boyden station at Arequipa, Peru, at an elevation of 8,000 feet. Although the construction of a doublet of such unprecedented size was strongly criticized in those days, the telescope has been effective, and is responsible for 16,000 negatives in the Harvard collection. The revelations from the Bruce plates include the faint ninth satellite of Saturn, Phoebe; numerous studies of the Magellanic Clouds, including the discovery in them of more than two thousand variable stars, and of the period-luminosity relation, one of the most effective measuring tapes for determining the scale of the universe. At least thirty thousand spiral nebulae have also been discovered by means of the Bruce telescope. Three other telescopes, for which the lenses were ground by the late Reverend Joel Metcalf, have taken about 45,000 photographs, on some of which over 2,500 variable stars have been discovered in the Milky Way regions. Forty-one minor planets were discovered by Dr. Metcalf on plates which he took with his 12-inch lens, plates later donated by Mrs. Metcalf to this observatory. For thirty years small photographic telescopes, with lenses of one-inch aperture, have patrolled the northern and southern sky, so that for observational work there are often semi-monthly plates of various parts of the sky, showing stars down to the eleventh or twelfth magnitudes. The Harvard Map of the Sky was made from these plates, from studies of which many variable stars and eighteen novae have been found. In 1927 the Boyden station was moved from Arequipa, Peru, to Bloemfontein, South Africa, by Dr. Shapley, fifth director of the observatory. Excellent prospects for a bright future in the photography of the southern stars are promised by modern mountings for the old instruments, a new Ross-Fecker lens for patrol work and a 60-inch reflector for detailed investigations. The prospective removal of the Cambridge photographic instruments to Oak Ridge in the town of Harvard, comparatively free from smoke and electric lights, will be of great advantage in the photography of the northern stars. And the completion of the new fireproof structure to house the negatives will insure for many years to come the usefulness of the Harvard Collection of Astronomical Photographs.

The chemistry of the photographic process: G. B. KISTIAKOWSKY.[1] The problem of the chemical processes that occur in the production of an image on a photographic plate has long been a very difficult one. It is possible to do little more than present the attitude of modern physicists and chemists towards theories of the way in which light acts on the silver salt grains in the photographic emulsion, and the way in which the silver salt (such as silver bromide) is changed, by developing the plate, into metallic silver. Observation shows that development starts at the edge of the microscopic grain, and that its occurrence depends on the presence of smaller specks of silver sulphide in the grain. These specks of silver sulphide are produced during the "ripening" of the emulsion (effected by adding ammonia to the emulsion, and heating) by a minute quantity of sulphur compound contained in the gelatin. The presence of this sulphur is due, curiously enough, to mustard plants in the diet of the cattle from whose bones the gelatin is made (and gelatin made from cattle whose diet contains no mustard is found to be inferior for this purpose). It seems possible that the bromine atoms travel around until they encounter these "sensitivity specks" of silver sulphide, and that a reaction then starts which makes the whole grain of emulsion developable. There was a hypothesis that the light quanta falling on the plate acted upon individual silver bromide molecules, separating them into silver and bromine; but this hypothesis seems to be refuted by several properties of the photographic emulsion, such as the fact that the light must be of a certain minimum strength to make an impression on the plate at all; very weak light produces no image. An important modern branch of photography treats of the action of certain dyes on the emulsion, making the plate sensitive to other colors than blue and violet. A noteworthy example of such a dye is the one used by the Eastman Kodak Company in making a plate that is sensitive to the infra-red rays of light that are invisible to the eye. The way in which the dyes work is very imperfectly understood. Much remains to be done in photography as an art, as distinct from photography as a science; and the fundamentals for understanding the reactions that are used in photography are the materials for further research by the chemist.

[1] Professor of Chemistry, Harvard University.

A survey of photographic astrometry: FRANK SCHLESINGER.[2] Pioneer work in photographic astrometry was done at the Harvard Observatory by Bond. Especial tribute should also be paid to the painstaking investigations which Rutherfurd made in his private observatory at 11th Street and Second Avenue, New York City. Rutherfurd showed definitely, as early as 1865, that star positions could be measured with great accuracy from photographic plates and that the much disputed distortion of the film did not affect the measurements seriously. Rutherfurd's early optimism was more than justified; at present one measurement from a photographic plate can compete in accuracy with ten visual measurements made with a telescope of the same focal length. In 1886 and 1887, conferences of some of the world's most prominent astronomers met in Paris to consider the project of making a photographic map of the whole sky containing stars one thousand times fainter than the faintest star visible to the naked eye. The accuracy with which star positions can now be photographically measured is very great; the accidental error of measurement is equal to only 0.000,020 inch, or 0.0005 mm. In conclusion, some of the most important future problems in this field should be mentioned. Our knowledge of the radial velocities of the stars (motions directly towards us or away from us) is very meager for the fainter stars. Progress in such work can only be expected after what may prove to be a long period of trial and experiment. Success in determining radial velocities by means of the objective prism does not look less promising to us now than was the prospect of determining radial velocities by any method forty years ago. The importance of being able to determine velocities in this way is so great as to warrant years of patient effort on the part of many workers. The importance must again be emphasized of a close cooperation between the astronomer and the chemist who specializes in the chemistry of photography. Astrometry will enter a new era if a method can be found for eliminating the inherent inaccuracies in the measurement of positions on the photographic plate. The cause of these inaccuracies is still to some extent a mystery, but it appears certain that the major source of inaccuracy lies in the plate itself and not in the methods now at hand for measuring it.

The current photographic programs of the Harvard Observatory: HARLOW SHAPLEY. Seven major observing programs and eleven smaller programs are in operation with the Harvard telescopes; nine instruments are in continual use on the programs at the Cambridge station, five at the South African station, and three special cameras with the meteor expedition at Flagstaff, Arizona. Nearly 15,000 photographs have been made since 1924 on the program of Milky Way variable stars—a research designed to give information on the structure and dimensions of the galactic system. The survey of the photographic brightness of the stars is to extend to magnitude 8.5, and includes approximately 120,000 stars over the whole sky; the photographs are made at Cambridge and at Bloemfontein, and are measured with the thermo-electric microphotometer. An extensive program on the motions of the nearby stars is carried on in cooperation with the University of Minnesota. Investigations dealing with the variable stars that have been selected for international cooperation are carried on in conjunction with the University of Missouri, Hood College, Cornell University, the Case School of Applied Science, Connecticut College, and several other institutions. The photographs are made at Harvard and measured at the other observatories. Only nine meteor spectra are now known—three on Harvard plates, three on Moscow plates, two from Mount Wilson and one from Hamburg. In the Harvard collection only about one spectrum plate in 20,000 shows spectra of meteors, but with special cameras it is hoped to get one spectrum out of every fifty to a hundred attempts. In the systematic sky patrol approximately 90,000 photographs have been accumulated—all on glass negatives, 8 x 10 inches in size. These plates form the basis of numerous investigations of variable stars and stellar distribution. Cooperative programs dealing with the structure of the stellar universe are carried on in conjunction with the astronomical departments of Amsterdam and Groningen; for the Groningen work the photographs are taken on specially made plate glass plates. Other active researches at the Harvard Observatory deal with the discovery and measurement of extragalactic nebulae, and with the less remote globular clusters, and the Magellanic Clouds. The classification of the spectra of faint stars in interesting regions is a special problem of the highest importance. A number of special photometric programs, including the determination of standard photographic sequences and the establishment of systems of photovisual and red magnitudes, are also in active operation.

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

BUSINESS PROCEEDINGS OF THE EXECUTIVE COMMITTEE

THE executive committee of the council of the American Association for the Advancement of Science met on Saturday, April 23, and Sunday, April 24, in Washington, D. C. Since the executive committee acts for the council when it is not in session, the following items of business transacted are to be interpreted as actions of the council:

1. The Genetics Society of America and the American Sociological Society were accepted as affiliated societies.

[2] Director of the Yale University Observatory.

2. The defunct American Federation of Teachers of the Mathematical and Natural Sciences and the Botanists of the Central States were dropped from the list of affiliated societies.

3. A constitutional amendment to permit each division to name two council representatives was ordered brought before the council at Atlantic City.

4. The proposal that the association cooperate with Sigma Xi in commemorating the fiftieth anniversary of its founding at Cornell University was discussed and the permanent secretary was asked to secure from the society possible alternatives for such cooperation for consideration at the next meeting of the Executive Committee.

5. The resignation of Dr. A. G. McCall as auditor was accepted and Dr. W. J. Humphreys was elected auditor.

6. The executive assistant was authorized to sign checks drawn against the checking account No. 1 of the Association in the American Security and Trust Company. In the absence or inability of the executive assistant the checks are to be signed by the permanent secretary. A joint bond of $20,000 to cover the responsibility of the executive assistant and the permanent secretary was ordered.

7. $15,000 now in the reserve funds of the office of the permanent secretary were ordered transferred to the treasurer for investment in such a manner as to remain subject to the order of the officers of the association. The permanent secretary was authorized to invest $5,000 in U. S. Treasury Certificates, purchase to be made from reserve funds of the office of the permanent secretary. The balance of the permanent secretary's reserve funds were ordered deposited in savings accounts of two Washington banks.

8. A report on the Hector Maiben bequest from Mr. Wm. G. Long, Seattle attorney, was accepted. It was reported that the appraised value of the estate, fixed by the court, amounted to $37,833.40. Inheritance tax and administration fees will be deducted from this amount. An honorarium of $150 was voted for Mr. Wm. G. Long in appreciation of his services, this sum to be paid from the treasurer's current funds. Mr. Ben Maiben, brother of Hector Maiben, was appointed as the association's local representative in Nebraska with authority to act in all cases where problems or exigencies may arise in connection with securities on property in Nebraska obtained through the will of his brother.

9. In memory of Hector Maiben, a Hector Maiben lecture to be given each year at the annual (winter) meeting of the association was established. This lecture will carry an honorarium of $200 and traveling expenses for the lecturer. The first Maiben lecture will be held at Atlantic City.

10. The expenses of the secretary of the academy conference in attending the annual meeting were authorized to be paid on the same basis as expenses of section secretaries.

11. It was voted that members of the executive committee attending the meetings of the committee at Syracuse will be expected to pay their own expenses.

12. It was voted to pay expenses of only those section secretaries who take an active part in arranging programs for the Syracuse meeting.

13. A new half year membership at one half the regular annual dues was authorized for those joining the association between April 1 and October 1. Such new members will receive a journal subscription for the six months beginning July 1. Members joining under this plan will be billed for a regular year's membership at the time of the October billing.

14. An additional appropriation of $649.12 was made to cover over-expenditures of the Science Exhibition committee at New Orleans. Total expenditures were reported as $3,149.12.

15. A letter from Dr. Otis W. Caldwell, chairman of the Committee on the Place of Science in Education, was read, recommending that the committee be discharged, and that the unexpended balance of the committee's funds be held in the association's reserves. The report was accepted and the permanent secretary was asked to confer with Dr. Caldwell.

16. The president and the chairman of the executive committee were asked to select a delegate to attend the meeting of the British Association for the Advancement of Science to be held in York, England, August 31 to September 7.

17. It was voted to hold the next fall meeting of the executive committee in Atlantic City on the third Saturday and Sunday in October.

18. The committee adjourned to meet in Syracuse on June 20.

CHARLES F. ROOS,
Permanent Secretary

SCIENTIFIC APPARATUS AND LABORATORY METHODS

A SHORT METHOD FOR CALCULATING MOISTURE PERCENTAGES[1]

THE determination of moisture is an essential part of many analytical procedures and the calculations involved are somewhat tedious. Careful checking is required to prevent errors. The use of a calculating machine naturally increases the speed and accuracy of the work. In connection with a large number of routine analyses, a short method of computing moisture percentages with the aid of a calculating machine

[1] Approved for publication by the chief, U. S. Bureau of Chemistry and Soils.

was devised which may be of interest to others. This method reduces the time required since only four figures need be recorded in the machine until the moisture percentage is obtained. By any other method familiar to the author, seven to nine operations and the writing down of intermediate figures are necessary. The method can best be explained by means of an example, in which it is assumed that an 8 row, 3 dial machine is available. Minor differences in other makes and models of calculating machines, particularly, a different number of rows of keys, introduce slight modifications in technique which should be obvious to an experienced operator.

Problem: What is the moisture content, on a dry weight basis, of a sample of soil, the following data having been obtained in the laboratory?

Weighing bottle + air-dry soil	32.5868 grams
Weighing bottle + oven-dry soil	32.3676 grams
Weight of empty weighing bottle	29.3306 grams

Procedure: During the operations, put all numbers on the right-hand side of the keyboard, maintaining a constant position for the decimal point. Move the pointers over the dials to the positions shown by the arrows in order to indicate the position of the decimal point during the operations. Move the carriage as far as it will go toward the right and put the weight of the bottle plus air-dry soil in the carriage dial. The dials then appear as follows:

```
      ↓                ↓
0 0 3 2 5 8 6 8    1 0 0 0 0 0 0 0
        ↓                ↓
0 0 0 3 2 5 8 6 8 0 0 0 0 0 0 0 0
```

Next move the carriage as far as it will go toward the *left* and put the weight of the bottle plus oven-dry sample on the *right* side of the carriage dial:

```
      ↓                ↓
0 0 3 2 3 6 7 6    1 0 0 0 0 0 0 1
        ↓                ↓
0 0 0 3 2 5 8 6 8 0 3 2 3 6 7 6
```

Now put the weight of the empty weighing bottle on the keyboard and subtract it from each set of figures by sliding the carriage from one end to the other, and subtracting with the carriage at each end. The dials now show:

```
      ↓                ↓
0 0 2 9 3 3 0 6    0 0 0 0 0 0 0 0
        ↓                ↓
0 0 0 0 3 2 5 6 2 0 0 3 0 3 7 0
```

These figures in the carriage dial are the weights of the air-dry and oven-dry samples, respectively, and need not be noted unless desired. Clear the keyboard and put the weight of the oven-dry sample (the figures on the right-hand side of the carriage) on the keyboard and subtract from both sides as explained above. If no mistake was made in transferring the figure, the numbers on the right side of the carriage become zero, thus automatically checking the transferred number, and those on the left represent the loss in moisture of the sample. The dials at the end of this operation appear as follows:

```
      ↓                ↓
0 0 0 3 0 3 7 0    8 9 9 9 9 9 9 9
        ↓                ↓
0 0 0 0 0 2 1 9 2 0 0 0 0 0 0 0
```

The machine now has the weight of the moisture near the left center of the carriage dial and the weight of the oven-dry sample on the keyboard, thus it is correctly set for dividing the first by the second to obtain the percentage of moisture. Clear the *upper right-hand* dial before starting the division, which is performed in the usual manner. In the example given, the moisture content is 7.217 per cent.

This figure, plus 100.0 per cent., gives a factor by which all other analytical data, expressed in percentage of the fresh sample, can be converted to percentage on the dry-weight basis. Thus if the silica content of the soil in the preceding example is 61.54 per cent. on the basis of an air-dried sample, it is 61.54×1.0722, or 65.98 per cent., on the oven-dry basis.

The operation is the same for samples containing over 100 per cent. moisture, expressed on a dry-weight basis. In this case, however, the factor for converting the fresh-weight to dry-weight percentage is correspondingly large. For example, if the dry-basis nitrogen percentage of a sample of soy-beans is desired and the moisture and nitrogen determinations of the fresh material gave the following data,

Weighing bottle + fresh plant	45.2768 grams
Weighing bottle + dry plant	32.9884 grams
Weight of empty weighing bottle	29.3306 grams
Nitrogen, fresh-weight basis	0.58 per cent.

the calculation of the moisture content gives 335.95 per cent. on a dry-weight basis and the conversion factor is therefore

$$3.3595 + 1.0000 = 4.3595,$$

hence the nitrogen content on the dry-weight basis is

$$.58 \times 4.3595 = 2.53 \text{ per cent.}$$

With the increasing dependence upon machine calculation, simplified methods similar to this have probably been devised by other investigators, although a limited search of the literature has failed to disclose published references. Therefore the above method is offered to those who may be interested in a simple,

rapid and accurate procedure for handling moisture calculations.

NELSON MCKAIG, JR.
BUREAU OF CHEMISTRY AND SOILS,
U. S. DEPT. OF AGRICULTURE,
HOUMA, LOUISIANA

A BALANCE FOR LIVE ANIMALS

CERTAIN experiments in this laboratory have necessitated recording every week the weight of large numbers of rats. A spring balance was found to be unsatisfactory for two reasons, it does not read correctly over a range of 0 to 400 grams, and the movements of a rat on the pan cause such wide oscillations of the pointer that accurate reading is impossible. An ordinary beam balance has the additional disadvantages of being slow in operation because of the time required to manipulate weights, and of being even more affected than the spring balance by the movements of the rat.

The addition of a simple attachment to a commercial direct-reading beam balance gave such satisfactory results that we believe other workers may be glad to have a description of the device. The balance is one of those commercial balances of 1 kilo capacity, reading directly from 0 to 100 grams in one gram intervals, in which the oscillations of the beam are damped by a paddle attachment immersed in oil. Such a balance is most useful for general laboratory purposes, and even for weighing animals. Its performance may be considerably improved, however, by additional damping to overcome the oscillations caused by movements of the animal on the scale pan. We have achieved this by attaching to the underside of the scale-pan a paddle immersed in oil. This successfully damps the sideways or rotatory oscillations. A cup-shaped pan was adopted because rats move about in it very much less than on the ordinary scale-pan. The oscillations of the pointer due to movements of a rat are in this way practically eliminated.

As many as three hundred weighings of rats, accurate to within 1 gram, may, with this apparatus, be made easily in one hour.

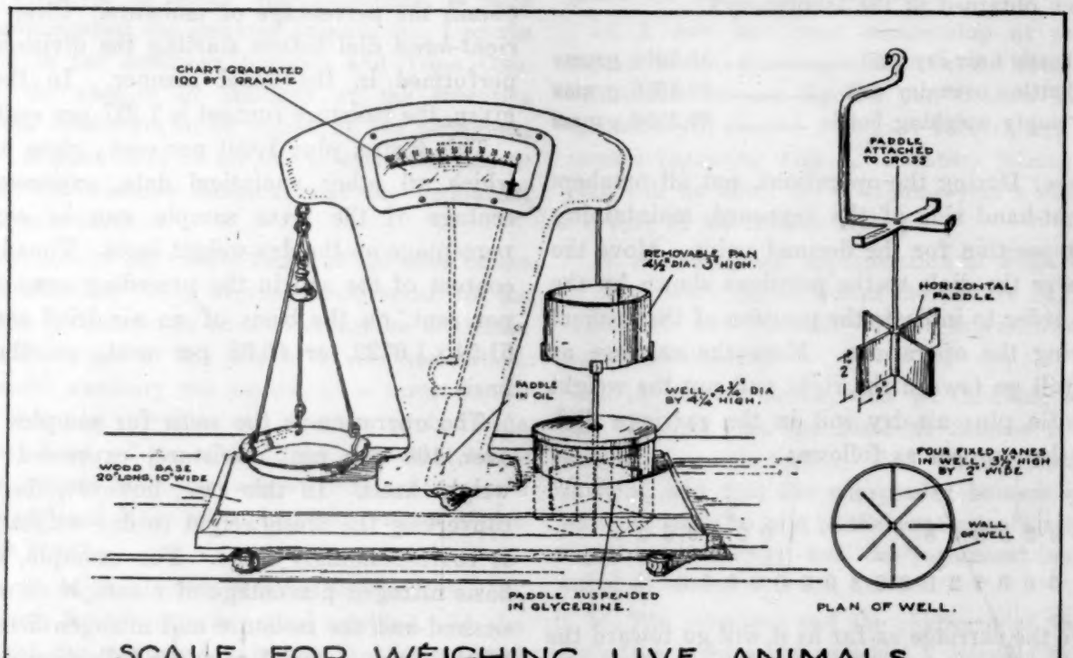


CHART GRADUATED 100 BY 1 GRAMME
REMOVABLE PAN 4½" DIA. 3" HIGH.
PADDLE IN OIL
WELL 4¾" DIA BY 4¾" HIGH.
WOOD BASE 20" LONG, 10" WIDE
PADDLE SUSPENDED IN GLYCERINE.
PADDLE ATTACHED TO CROSS
HORIZONTAL PADDLE
FOUR FIXED VANES IN WELL, 3½" HIGH BY 2" WIDE
WALL OF WELL
PLAN OF WELL.

SCALE FOR WEIGHING LIVE ANIMALS.

Messrs. W. and T. Avery, of Toronto, who are the makers of the commercial balance which we have adapted, were good enough to construct the additional attachments for us.

BRUCE F. CROCKER
HARDOLPH WASTENEYS
DEPARTMENT OF BIOCHEMISTRY,
UNIVERSITY OF TORONTO

SPECIAL ARTICLES

THE CHEMICAL STUDY OF INSULIN[1]

CRYSTALLINE insulin was first prepared by Abel in 1926.[2] Since then it has been of the greatest interest to ascertain the chemical structure of this substance, which plays so important a rôle in carbohydrate

[1] No. 13 of the series "Studies on Crystalline Insulin." Investigations carried out under grants from the Carnegie Corporation of New York and the Eli Lilly Company, Indianapolis, Indiana.

[2] J. J. Abel, *Proc. Nat. Acad. Sci.*, 12, No. 2, 132, 1926; Abel, Geiling, Rouiller, Bell and Wintersteiner, *J. Pharmacol. and Exp. Therap.*, 31, 65, 1926.

metabolism. It was found that crystalline insulin was of characteristic protein nature, possessing a high sulfur content of 3.2 per cent.[3] Naturally, the question arises whether this crystalline protein is identical with the hormone itself, possessing therefore its specific hypoglycemic action, or whether the protein crystal acts simply as a convenient carrier, the true hormone being adsorbed or loosely bound to the protein surface. The assumption that the crystalline protein is the hormone itself is based upon the following evidence.

Crystalline insulin possesses the maximal amount of physiological activity thus far obtained from insulin preparations, namely, 24 international units per milligram.[4] Attempts to obtain more active products have failed.[5] The preparation, as claimed by Dingemanse,[6] of an amorphous substance four times as potent as crystalline insulin, but extremely unstable, could not be repeated by workers in other laboratories[7] so that further proof is necessary before this can be generally accepted. The physiological activity of the crystals is independent of the method of their preparation[8] and also of the source of the pancreatic tissue from which they are obtained. Crystalline insulin has been prepared from the islet tissue of certain fishes[9] and from pig and sheep pancreas.[10] Insulin crystals obtained from these various sources all possess the same activity, approximately 24 units per milligram, and all have the same sulfur content, 3.2 per cent.[11] All the evidence thus far obtained favors the assumption that this crystalline protein represents the hormone insulin in its purest and most active form.

It may be added here that the ease with which one can obtain crystalline insulin varies, as does the yield, with the commercial product used for its preparation.[12] Using the proper preparation (in this laboratory Squibb's commercial product has given the best yield) satisfactory amounts of crystalline insulin can be obtained. In contradiction to a statement in *Nature*[13] the yield of crystalline insulin in terms of activity is about 50 per cent., using the Squibb's commercial material. It has been shown in this laboratory that the initial hyperglycemia produced by commercial insulin preparations is a non-hormonic action due to the impure nature of these preparations.[14]

It is of fundamental importance to decide whether the activity of insulin is a function of the whole molecule or of a prosthetic group, non-proteid in composition, which is attached to the protein complex. The latter situation exists in the case of hemoglobin, in which globin is the protein component and hematin (an iron-pyrrole compound) constitutes the prosthetic group. However, hematin, which is easily separable from the original molecule, is incapable of assuming the function of hemoglobin in the blood. In the case of crystalline insulin efforts to show the presence of such a prosthetic group, chemically different in its composition from ordinary amino acids, have thus far failed. As yet there is no evidence that such a constituent is present in the crystalline protein.

If one does not assume that the insulin molecule as a whole is responsible for the physiological action another possibility demands consideration. A grouping of certain component amino acids embedded in the molecule may be responsible for the hypoglycemic effect of insulin. In the case of the thyroid protein, iodothyreoglobulin, the physiological activity is a property, not of the protein as a whole, but of a specific constituent, thyroxine, which, moreover, is readily separable from the rest of the molecule.[15] Various attempts to separate such an active component from the insulin molecule have resulted in inactivation. The possibility exists, of course, that an active intramolecular complex, if present, is so unstable that it decomposes as rapidly as it is liberated. Investigation of the intact insulin molecule, therefore, would be necessary to establish the presence of a similar component. Could one definitely assign specific physiological activity to such a group, it is still possible that this constituent, when isolated from the molecule as a whole, would not show all the specific physiological actions of insulin.

The investigation of the possible existence of such groupings in the insulin molecule may be approached in two ways, first, one may separate and characterize the different amino acids obtained by hydrolysis. This method in addition will allow the identification of any constituents in the molecule other than amino acids. Secondly, one might also establish the presence

[3] Abel, Geiling, Rouiller, Bell and Wintersteiner, *J. Pharmacol. and Exp. Therap.*, 31, 65, 1926.

[4] Jensen, Wintersteiner and Geiling, *J. Pharmacol. and Exp. Therap.*, 36, 115, 1929.; Freudenberg and Dirscherl, *Zeit. physiol. Chem.* 180, 212, 1929; Harington and Scott, *Biochem. J.*, 23, 384, 1929.

[5] duVigneaud, Geiling and Eddy, *J. Pharmacol. and Exp. Therap.*, 36, 125, 1929; Jensen and DeLawder, *J. Biol. Chem.*, 87, 701, 1930.

[6] Dingemanse: *Arch. néerl. physiol.*, 12, 259, 1927; van Bronkhurst, *Pharmaceutisch weekblad*, 26, 641, 1930.

[7] See reference 5 and Dirscherl, *Zeit. physiol. Chem.*, 202, 116, 1931.

[8] Harington and Scott, *Biochem. J.*, 23, 384, 1929.

[9] Jensen, Wintersteiner and Geiling, *J. Pharmacol. and Exp. Therap.*, 36, 115, 1929.

[10] Scott, *J. Biol. Chem.*, 92, 281, 1931.

[11] See references 9 and 10.

[12] Jensen, Wintersteiner and Geiling, *J. Pharmacol. and Exp. Therap.*, 36, 115, 1929; Jensen and DeLawder, *Zeit. physiol. Chem.*, 190, 262, 1930.

[13] *Nature*, 126, 810, 1930.

[14] Geiling and DeLawder, *J. Pharmacol. and Exp. Therap.*, 39, 369, 1930.

[15] See reference 8.

of physiologically active groups by treating insulin with chemical reagents having a precise action on certain specific arrangements in the molecule. Investigation of the insulin molecule by these two methods has been in progress in this laboratory since the crystallization of insulin. The expensive nature of the material makes it imperative to use only small quantities for chemical manipulation. In conjunction with the time-consuming assay of the products of chemical treatment this has made progress somewhat slow.

Earlier publications from this laboratory have shown the presence of the following amino acids in the insulin molecule: cystine, about 12 per cent.; tyrosine, about 12 per cent.[16]; and arginine, histidine, lysine and leucine.[17] These amino acids are not sufficient to account for the total nitrogen of insulin. Determination of the distribution of nitrogen in the crystalline protein also indicates the presence of amino acids other than those listed above. In cooperation with Dr. Wintersteiner at Columbia University, New York, I have therefore undertaken anew the hydrolysis of insulin with somewhat larger amounts (4 grams). Only workers in this field will realize the difficulties of isolating various amino acids from such a small amount of original material. One can only hope for a renewed study of the chemical properties and quantitative separation of the various amino acids. Such a research would prove invaluable, not only in the study of insulin, but also for the chemical investigation of other biologically important compounds, protein in nature, and available only in comparatively small amounts.

The new hydrolysis of insulin reveals that the protein is composed of relatively few amino acids. Besides those already mentioned glutamic acid has been isolated and identified.[18] According to the amount of ammonia nitrogen (9.58 per cent. of total nitrogen) found in the determination of the nitrogen distribution in insulin,[19] a comparatively large amount of this amino acid should be present. Evidence of the presence of hydroxyvaline has also been obtained and, furthermore, leucine was found to be present in relatively large amounts. The presence of proline seems doubtful. No evidence for the presence of any other amino acids, or of any other constituent differing in its composition from an amino acid, could be obtained. We, therefore, find the following amino acids in the insulin molecule: cystine, tyrosine, glutamic acid and leucine, each present in quantities of more than 10 per cent.; and histidine, arginine, lysine, hydroxyvaline and proline (the last two are doubtful) in smaller amounts. The details of our work on the hydrolysis of insulin will be published elsewhere.[20]

The problem of linking the physiological activity of insulin to certain amino acid groups has been approached in two ways. First, various derivatives of insulin were prepared and their activity studied. The fundamental idea underlying these experiments was to block the active group or groups and thus to obtain a compound of no or greatly diminished activity. Then, by splitting off the radical which had been introduced into the active group, one might obtain a product, either equally as active as the original crystalline insulin, or at least of higher activity than the unhydrolyzed "blocked" substance. In undertaking these experiments one must bear in mind the marked instability of insulin. By treating insulin with acetic anhydride, acetyl insulin is obtained either with greatly diminished activity[21] or in a completely inactive form.[22] Hydrolysis of the acetyl insulin gives a product of an activity higher than that of the acetylated compound but lower than that of the original insulin. Under the conditions employed acetylation is possible at $-OH$, $-NH_2$ and $=NH$ groups. It is logical to conclude, therefore, that the acetylated group or groups are of importance in the physiological action of insulin.

The treatment of insulin in weakly alkaline solution with benzaldehyde and other aldehydes yields completely inactive products. Reactivation of these compounds has thus far been unsuccessful.[23] Here again one may conclude that the active group or groups have been blocked.

Insulin, when allowed to stand in acid alcohol for several hours, gives a completely inactive product. On treatment of this compound with very dilute alkali, about 60 per cent. of the activity is regained.[24] The hydrolyzed product may be partly obtained again in crystalline form identical with the original crystalline insulin.[25] Various investigators ascribe the inactivation to the blocking of the active group or groups

[16] duVigneaud, Jensen and Wintersteiner, *J. Pharmacol. and Exp. Therap.*, 32, 367, 1928.

[17] Jensen, Wintersteiner and duVigneaud, *J. Pharmacol. and Exp. Therap.*, 32, 387, 1928.

[18] Jensen, *J. Biol. Chem.* (in press).

[19] Wintersteiner, duVigneaud and Jensen, *J. Pharmacol. and Exp. Therap.*, 32, 397, 1928.

[20] Jensen and Wintersteiner, *J. Biol. Chem.* (in press).

[21] Jensen and Geiling, *J. Pharmacol. and Exp. Therap.*, 33, 511, 1928; Freudenberg and Dirscherl, *Zeit. physiol. Chem.*, 175, 1, 1928; Freudenberg, Dirscherl and Eyer, *Zeit. physiol. Chem.*, 187, 95, 1930; Jensen and DeLawder, *Zeit. physiol. Chem.*, 190, 262, 1930.

[22] Charles and Scott, *Trans.* Royal Soc. Canada, Section v, 187, 1931.

[23] Jensen and DeLawder, *Zeit. physiol. Chem.*, 190, 262, 1930; Freudenberg, Dirscherl and Eyer, *Zeit. physiol. Chem.*, 202, 144, 1931.

[24] Carr, Culhane, Fuller and Underhill, *Biochem. J.*, 23, 1010, 1929; Charles and Scott, *J. Biol. Chem.*, 92, 289, 1931; Freudenberg, Dirscherl, Eyer, *Zeit. physiol. Chem.*, 202, 133, 1931.

[25] Charles and Scott, *J. Biol. Chem.*, 92, 289, 1931.

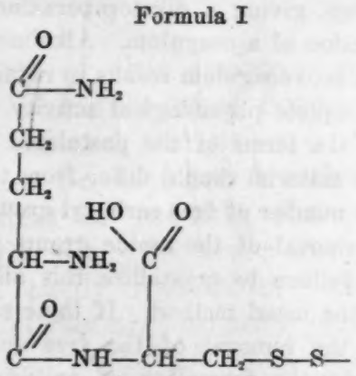
by methylation (using methyl alcohol) of the –OH, $-NH_2$ and =NH group or to the esterification of the –COOH group. Treatment with dilute alkali removes the methyl radical with the subsequent regeneration of the active groups. Later in this paper I shall propose a further explanation for this reaction.

The reduction of insulin, even under the mildest conditions, gives an inactive product which thus far has been found incapable of reactivation. Under the conditions employed probably only the disulfide linkage is affected. Since insulin gives no positive test for the sulfhydryl group it is generally assumed that all the sulfur is present as the disulfide linkage. In my opinion the total sulfur of insulin exists as cystine in the molecule. Even such mild reducing agents as cysteine and glutathione will apparently reduce the disulfide linkage, giving a physiologically inactive product which can not be reactivated.[26] It has been found that under mild conditions initial inactivation coincides with the first appearance of a positive sodium nitroprusside test for the sulfhydryl group.[27] In the above experiments the inactivation of insulin resulted from the alteration of certain physiologically important groups, without, however, removing these groups from the original molecule.

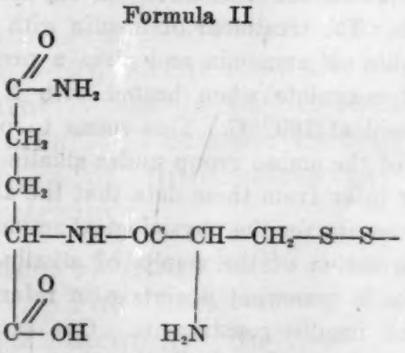
A second line of attack consists in splitting off such active groups and then determining the particular amino acid affected by this treatment. If insulin is heated with N/10 hydrochloric acid in a boiling water bath, an inactive coagulum is obtained. Treatment of this coagulum with dilute alkali gives a product, the activity of which is practically equal to that of crystalline insulin.[28] In spite of its high activity, efforts to recrystallize this material by the usual method have failed.[29] duVigneaud and coworkers[26] express the view that the formation of a coagulum under these conditions is specific for insulin and that the physiologically important groups are involved in this reaction. I shall return to this reaction later. It has also been pointed out in earlier communications from this laboratory that insulin, under the influence of alkali, not only splits off sulfur,[30] but also ammonia.[31] A later and more detailed study of this reaction[32] indicates that treatment of insulin even with very dilute alkali liberates ammonia and leads to the formation of an inactive product. There seems to exist a correlation between the degree of inactivation and the amount of ammonia given off. Under these same conditions the sulfur of insulin is also affected. Thus far it has not been possible to inactivate insulin irreversibly without removing at least a part of its sulfur, and it may be doubted whether one can remove a part of the sulfur without affecting the activity. In opposition to this point of view Freudenberg and his coworkers[33] assume that the sulfur of the insulin molecule plays no rôle in the action of its active component. If one affects only a very small part of the sulfur, as in Freudenberg's experiment, the unfortunate variations of the physiological assay may prevent the clear indication of the resultant slight inactivation. This point is under a more thorough investigation in this laboratory at the present time.

These experimental findings, in conjunction with others omitted because of their detailed nature, have led me to postulate the characteristic constituent of the insulin molecule as composed, wholly or in part, of glutamic acid and cystine and having the following chemical structures:

Formula I



Formula II



I am quite aware that I am unable at the present time to furnish exact proof that the glutamic acid is linked to cystine as indicated in the above formulae. These structures are proposed only as a working

[26] duVigneaud, Fitch, Pekarek and Lockwood, *J. Biol. Chem.*, 94, 233, 1931.

[27] Unpublished results.

[28] duVigneaud, Geiling and Eddy, *J. Pharmacol. and Exp. Therap.*, 33, 497, 1928; Freudenberg and Coworkers, *Zeit. physiol. Chem.*, 180, 223, 1929; 187, 91, 1930; 202, 131, 1931.

[29] Jensen and DeLawder, *Zeit. physiol. Chem.*, 190, 262, 1930.

[30] Abel and Geiling, *J. Pharmacol. and Exp. Therap.*, 25, 423, 1925.

[31] Jensen, Wintersteiner and duVigneaud, *J. Pharmacol. and Exp. Therap.*, 32, 388, 1928; Wintersteiner, duVigneaud and Jensen, *J. Pharmacol. and Exp. Therap.*, 32, 410, 1928.

[32] Jensen and DeLawder, *Zeit. physiol. Chem.*, 190, 270, 1930; Freudenberg, Dirscherl and Eyer, *Zeit. physiol. Chem.*, 187, 192, 1930; 202, 129, 1931.

[33] Freudenberg, Dirscherl and Eyer, *Zeit. physiol. Chem.*, 187, 100, 1930.

hypothesis on which to base further efforts toward the elucidation of a possible specific constituent of insulin.

The action of acids and alkali on insulin to which I have already referred has been studied in more detail by E. A. Evans, Jr., and myself. The results thus far obtained seem to support the postulation of the above grouping in the insulin molecule. Insulin, when heated with N/10 hydrochloric acid in a boiling water bath forms a coagulum with the simultaneous appearance of ammonia. Upon redissolving this precipitate in very dilute alkali and again subjecting the material to the original acidity and temperature, a second coagulum is obtained with the separation of much less ammonia than before. The formation of this acid insoluble coagulum indicates a decrease in the basicity of the protein molecule, such as would result, in the case of the postulated grouping (formula I), from the condensation of the amide group and the amino group with the elimination of ammonia. Solution of this condensation product in alkali would open the lactam ring with the regeneration of the carboxyl group. In case of formula II the ammonia is derived from the amide group, and the condensation of the amino group with the free carboxyl group, giving a diketopiperazine, accounts for the formation of a coagulum. Alkaline treatment of the insulin acid coagulum results in regaining practically the complete physiological activity of crystalline insulin. In terms of the postulated structures, however, this material should differ from the original insulin in the number of free carboxyl groups present, due to the removal of the amide group. This may explain the failure to crystallize this alkali-treated material by the usual method. If these assumptions are correct, the removal of the free amino group should prevent the formation of an acid insoluble coagulum. The treatment of insulin with very dilute alkali splits off ammonia and gives a product which does not coagulate when heated with N/10 hydrochloric acid at 100° C. This seems to point to the removal of the amino group under alkaline treatment. One may infer from these data that the amide group is not necessary for the physiological action of insulin.

Interpretation of the results of alkaline treatment of insulin is somewhat uncertain in reference to the postulated insulin constituents. One can only conclude from the study of alkali action on insulin that the sulfur, or at least a part of it, as the disulfide linkage, and also a free amino group are necessary for physiological activity. The inactive product of alkali treatment gives only a very weak ninhydrin reaction in contrast to the strongly positive test of crystalline insulin. This suggests, though the question remains unsettled, that the ammonia given off by alkaline treatment originates from the physiologically important amino group. The details of the experimental work involved in these conclusions will be published elsewhere.[34]

Reference must also be made to the following experiment. Treatment of insulin with acid alcohol produces a physiologically inactive product giving a negative ninhydrin reaction. Subjecting this material to the action of dilute alkali restores most of the activity with the simultaneous reappearance of the positive ninhydrin reaction of the original insulin. One may explain this by assuming that the carboxyl group of the cystine (formula I), or of the glutamic acid (formula II), after esterification, reacts with the free amino group to form a diketopiperazine. The resultant blocking of the free amino group accounts for the negative ninhydrin reaction. Alkaline treatment opens the diketopiperazine ring with the regeneration of the original molecule, and also of the free amino group which reacts with ninhydrin. These results are also treated in more detail elsewhere.[34]

Although these findings may be explained in terms of the postulated active constituents of insulin, further proof is necessary to establish the validity of these assumptions. It hardly needs to be said that the results can also be explained by assuming a similar combination of another amino acid, such as tyrosine or leucine, with cystine. I believe, however, that cystine is of importance and is a part of the possible active constituent. The similarity in the physiological action of insulin and glutathione suggests glutamic acid as a possible constituent of the active group. The determination of the amino acid, to which the free amino group is attached, is important. The research is being continued in this direction and the synthesis of cystine peptides having the postulated structures is also being attempted. I wish to propose this hypothesis in only the most cautious and tentative manner until further data, either supporting or opposing the postulated structures, are available.

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[34] Jensen and Evans, *Zeit. physiol. Chem.* (in press).